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NPS Team World Leader in Network-Controlled Maritime Nuclear Radiological Detection

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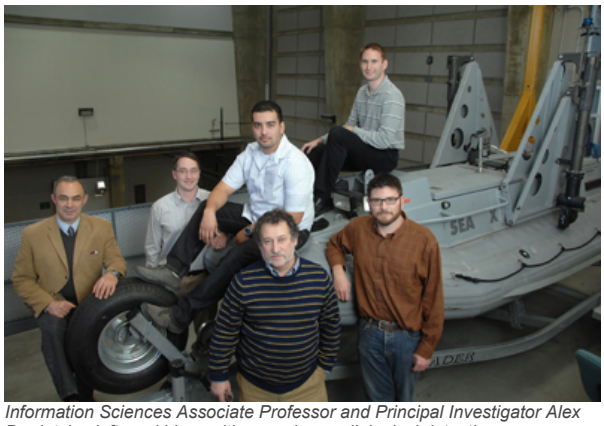
For five years, a Naval Postgraduate School team led by Principal Investigator Prof. Alex Bordetsky has pushed the envelope of network controlled stand-off nuclear radiological threat detection through a unique program of Tactical Network Topology (TNT) Maritime Interdiction Operations (MIO) field experiments jointly conducted by the NPS Center for Network Innovation and Experimentation (CENETIX) and Lawrence Livermore National Laboratory (LLNL).

"This is a high priority international counterterrorism effort that purposefully pushes the limits of synergistic communication and collaboration among sea, air and land sensors; remote operators and subject matter experts; front line first responders; special operations forces; homeland security and maritime personnel; and information fusion Tactical Operation Centers," explained Bordetsky, an associate professor of Information Sciences and CENETIX director. "It is supported by, amongst others, the U.S. Department of Energy, Special Operations Command, Coast Guard, San Francisco Bay Area first responders, the Port Authority of New York and New Jersey and numerous overseas partners including NATO's Maritime Interdiction Training Center. We also have active participation by overseas partners from Sweden, Germany, Greece, Denmark and Singapore."

The goal of the NPS-LLNL MIO program is a layered, wirelessly networked, globally integrated nuclear radiological detection, warning and interdiction system in which remote radiation source experts and biometric data analysts at geographically distributed command centers can actively see, hear and evaluate data online in near real time from tagged and tracked small maritime targets, including video feeds and text messaging, to guide further surveillance and collection needed by decision makers.

"NPS Dean of Research Karl Van Bibber has called our unique campaign of experimental studies in man-machine integration using collaboration in cyberspace a new direction in science," Bordetsky noted.



Information Sciences Associate Professor and Principal Investigator Alex Bordetsky, left, and his maritime nuclear radiological detection experimental team gathered around the "Sea Fox" autonomous surface vehicle dry docked at the NPS Center for Autonomous Vehicle Research (CAVR). Clockwise left to right: Bordetsky, Research Associate and doctoral student Sean Kragelund, CAVR Lab Manager and Computer Science student Aurelio Monarrez, Ph.D. student and Research Associate Mike Clement, Research Associate Tad Masek, and Senior Researcher Eugene Bourakov.

"Historically, MIO experimentation emerged out of earlier collaboration among geographically distributed Special Forces ISR [intelligence, surveillance and reconnaissance] units using cyberspace to track high-value targets," Bordetsky explained. "In 2004, the first German, Swedish, Greek and Singapore officer students did this for their thesis research here at NPS and then set it up when they returned to their countries. We wouldn't have been so successful in developing the international portion of the experimental program if we hadn't had these student ambassadors. Then in 2005, we joined forces with Lawrence Livermore to develop ad hoc mobile self-organizing mesh networks in support of nuclear threat detection and interdiction for both large and small vessels."

"The heart of CENETIX's experimental program is our interdisciplinary faculty-student team," Bordetsky said. "We have the whole spectrum of NPS students – from Information Systems, Information Operations, C4I, and Defense Analysis/Special Operations, with which we enjoy a special relationship."

"The strongest facet of this research is that it brings researchers together with actual operators," said Research Associate and Ph.D. student Sean Kragelund, who has worked with the group's first surface robot, the Sea Fox, and was a mock combat swimmer for experiments on both the East Coast and in Greece. "Their participation adds value to the research results, and the experiments introduce new technology they can learn about and leverage, including unmanned vehicles, biometric identification devices and nuclear detection equipment."

"What I like best is that we've shown how to integrate swimmers and autonomous vehicles into the system so they become network nodes, feeding video to distant experts," added Mike Clement, also a doctoral student as well as research associate.

"Before, our swimmers were completely separated from the tactical network but now they're fully integrated as network nodes," agreed Senior Researcher Eugene Bourakov, formerly Technical Director for the Telecommunications Technology Institute at California State University, Hayward. "Our goal is for all of our gear to have not just tactical networking reach, but true global reach in near real time."

"My first day at work was the day we got the Sea Fox," said Aurelio Monarrez, Laboratory Manager for the NPS Center for Autonomous Vehicle Research, the autonomous boat's main operator and payload integrator, and an NPS undergraduate student in computer science. "It's a lot of fun and a great opportunity that I really appreciate. My coursework is directly related to my job, and my work schedule is flexible around my classes, both of which are huge."

The team's 2007 to 2009 experiments focused on network-enabled early detection and warning of nuclear related material at multiple overseas locations, tracking to its onloading onto small craft at points of departure, and detecting and interdicting the boats at multiple U.S. entry points. In fall 2008, the focus moved to a global threat scenario detecting, interdicting and searching for nuclear radiological material hidden in a large cargo ship, carried out jointly with the Port Authority of New York and New Jersey.

"The high priority the New York-New Jersey Port Authority places on maritime situational awareness for nuclear radiological material including improvised nuclear devices emerged out of their experiences surrounding September 11th," Bordetsky noted.

In 2010, Bordetsky's team expanded its experimental program to an even more ambitious range of operational scenarios.

"Two major recent thrusts are drive-by stand-off screening, detection and pursuit using high-speed fast boats, and bringing remote experts into instant support of front line first responders, mostly via remote operation of unmanned sensors including unmanned

NPS Stand-Off Nuclear Radiological Detection Team Senior Researcher Eugene Bourakov, center, integrates a German swimmer into the team's experimental tactical network for maritime interdiction operations.

surface vessels and unmanned aerial vehicles," Bordetsky said. "The on board radiation detector used in the drive-bys is the Adaptable Radiation Area Monitor [ARAM], which is able to detect, alarm and quickly identify likely radionuclides in real time."

"In MIO 10-2, beginning in June, we continued to explore new models for fusing networks, advanced sensors and collaborative technology in support of integrated interagency nuclear radiological detection countering small craft-sourced nuclear radiological threats. These 2010 scenarios included threat detection by network-enabled swimmers; choke point simulations; collaboration between U.S. experts and overseas operators in Germany and Greece on network-controlled choke point set up; modeling the application of unmanned surface vessels in support of small craft screening and pursuit by remotely-controlled maneuvering of overseas manned patrol boats; ground tracking of illicit material transfer; open water tracking of a source transfer to a sea port point of entry near an overseas NATO-U.S. installation; and collaboration among patrol crews from multiple countries in targeting small craft tracking, screening, pursuit and interdiction incorporating unmanned aerial vehicles.

Starting in March 2011, the San Francisco Bay portion of the NPS-LLNL MIO team's network-enabled detection program will develop a new direction incorporating real-time reachback to radiological experts into the daily patrols of Marine Police boat and Coast Guard vessel crews.

"For the first time, this will enable us to obtain long-term observational data on operational crews' daily networking and collaborative command and control patterns between and during radiological source detection events," Bordetsky noted. "This is a bring-your-own-boat, plug-and-play, real-world testbed where we set up virtual private networks [VPNs] in just a few hours."

"Recently, we've extended network controlled detection by bringing reports and sensor data provided by swimmers and unmanned robotic boats to the immediate assistance of remotely located detection experts," Bordetsky said.

"In June 2011. the network will be augmented first with pico [less than 1 kg] satellite-based ad hoc mobile orbital nodes assembled

and launched by CENETIX in cooperation with the NPS Space Systems Academic Group's Cube Satellite team," he added. "This will provide a new testbed capability for tracking covertly tagged targets and sharing detection findings via 'private' orbital nodes."

"One of the great things about this research is that you don't have failures," Bourakov said. "If something goes 'wrong,' you learn from it and do better the next time."

In addition to NPS and Lawrence Livermore, participants in the 2010 experimental program were Lockheed Martin's Center for Innovation, the Army Research Center at Picattiny Arsenal, the University of Bundeswehr in Germany, the Swedish Naval Warfare Center jointly with the Swedish Defense Research Agency, and NATO's MIO Training Center in Souda Bay.

"The success of this unique project," Bordetsky stressed, "is due to the talent and dedication of key CENETIX researchers. Eugene Bourakov provides an in invaluable contribution to the project by bringing innovations such as swimmer networking, adaptive antennas, voice control, electronic tags and taking care of the unique MIO testbed infrastructure. Other key members of the team are faculty members Michael Clement, Marianna Verett, John Looney, Sue Hutchins and Peter Guest; Ph.D. students such as Steve Mullins, Bryan Hudgens and Richard Bergin; partner faculty from a number of NPS departments; and an enthusiastic cohort of NPS master's thesis students who help in integrating MIO detection and the expert reachback network, design the experimentation tasks, play operational roles in the experiments, conduct data capture, and provide post-experiment analysis."

For more information about CENETIX research, go to http://cenetix.nps.edu/cenetix/.